UNIVERSITI PUTRA MALAYSIA

OPTIMIZATION OF MULCH MAT PRODUCTION FROM OIL PALM EMPTY FRUIT BUNCHES AND ITS EFFECTS ON GROWTH PERFORMANCE OF ACACIA HYBRID SEEDLINGS ON SANDY TAILINGS

WAN ASMA IBRAHIM

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By

WAN ASMA IBRAHIM

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Doctor of Philosophy

March 2006

DEDICATION

This thesis is dedicated to my late parents, my husband and children

Abstract of the thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Chairperson: **Associate Professor Datin Rosenani Abu Bakar, PhD**

Faculty: **Agriculture**

For forest plantation establishment on sandy soils such as tin tailings in Malaysia, mulching is important during transplanting of plants for moisture retention, protection of soil surface from erosion due to heavy rain and strong wind, regulating the soil surface temperature, reducing leaching of nutrients from fertilizers and weed control. EFB has been recycled as a mulch and source of nutrients in the oil palm fields and also has the potential for mulching forest species on sandy soils. However, the EFB in its natural form is heavy, thorny and bulky and cannot be stored. Therefore, the EFB need to be transformed into a form that is convenient and economical for mulching. Although the EFB is already commercially processed into a more convenient light form, it is too thin and has lost most of the EFB original beneficial characteristics. Thus, an improved thicker mats should be developed.

Earlier studies had shown that it was possible to produce mulch mat from EFB fiber using binders that allow the mat to decompose. However, the optimum processing

parameters to obtain the mats of targeted thickness were not determined and knowledge on its decomposition and effect on plant growth is greatly lacking. Therefore, the objectives of this study were to, (i) determine optimum parameters for making EFB mat which is thicker, capable of absorbing and retaining water and decomposes slowly, (ii) investigate its decomposition and (iii) determine its effect on the growth performance of Acacia hybrid planted on sandy tin tailings.

In determining the optimum parameters of making the EFB mats of 2 and 4 cm thickness, the following treatments were considered, (i) two binders, i.e. starch and polyvinyl acetate, (ii) four pressures, i.e. 500, 750, 1000 and 1250 psi, (iii) three binder concentrations, i.e. 1, 3 and 5% and (iv) two press times for each binder type, i.e. 2 and 4 min for starch and 1 and 2 min for polyvinyl acetate. The mulch mats produced were labelled accordingly where mats of 2 and 4 cm thickness made with starch binder were labelled MAT S2 and MAT S4, respectively. Mats of 2 and 4 cm thickness made with polyvinyl acetate binder were labelled MAT P2 and MAT P4, respectively. The chemical contents, water absorption and retention capacities of the mulch mats produced were also measured. Results showed that the optimum concentration of binder and press time were 3% and 2 minutes for making both MAT S2 and MAT S4. However, different pressures, i.e. 1250 and 1000 psi were required to make MAT S2 and MAT S4, respectively. For binder polyvinyl acetate, producing MAT P2 required 3% polyvinyl acetate solution, 1 min press time and a pressure of 1250 psi. For making MAT P4, 3% polyvinyl acetate binder solution, 2 min press time and a pressure of 750 psi was required. It was also found that drying was faster

for mats made with polyvinyl acetate binder. In general, the chemical contents of all the mats produced were similar (not significantly different) with values ranging from 0.42 - 0.67% N, 0.10 - 0.67% P, 2.09 - 3.09% K, 30.9 - 36.8% C, 0.14 - 0.28% Mg and 0.18 - 0.26% Ca, respectively. The water absorption were found to be highest in MAT P4 with a value of 268.1%.

Since the mats are biodegradable and could add organic matter to soil, a decomposition study was carried out on the 2 and 4 cm mats produced in the previous study in order to investigate the decomposition rate and nutrient release pattern. This study was carried out for 6 months under controlled conditions by placing the mat on sandy tin tailings in a container under a shelter with controlled watering. Destructive sampling was carried out every two weeks to determine the weight loss, pH, chemical contents (C, N, P, K, Ca and Mg) , lignin and holocellulose. Results showed that the decomposition rate of mat made with polyvinyl acetate binder of 4 cm thickness (MAT P4) was lower that all the other mats produced. However,the chemical compositions and nutrient release patterns of all the mats produced were found to be similar. Therefore, based on its shorter drying time, higher water absorption capacity and lower decomposition rate, MAT P4 was selected for application onto Acacia hybrid plants in the following study.

A field experiment was carried out using mini lysimeters in order to investigate the third objective. Acacia hybrid plants were planted in a container filled with sandy tin tailings and placed in an open space to grow for 4 months. Mulching was carried out

on the plants with MAT P4 and a commercial mat (CM) with different methods of fertilizer application. Nine treatments were carried out on the Acacia plants i.e., (i) Sand only (S), (ii) Sand with fertilizer applied (Sf), (iii) MAT P4 only (M), (iv) MAT P4 with fertilizer applied on top (Mt), (v) MAT P4 with fertilizer incorporated inside the mat (Mc), (vi) MAT P4 with fertilizer applied underneath the mat, (vii) Commercial mat only (CM), (viii) Commercial mat with fertilizer applied on top of the mat (CMt), and (ix) Commercial mat with fertilizer applied underneath the mat (CMb). Leachates were collected every two weeks. The parameters measured were the moisture contents of the soil and mat, the temperature of the soil, plant height, stem diameter, dry matter weights (DMW) after harvest, nutrient N, P, K, Ca and Mg uptake by plants, nutrient N, P, and K concentrations in the leachate and the soil properties before and after harvest.

Results showed that the thicker mat (MAT P4) was able to retain more moisture and regulate temperature better than the commercial mat (CM). Better growth performance in terms of increase in dry matter weight (DMW) and plant nutrient uptake was obtained from plants that were mulched with mulch mats in combination with fertilizer. Higher DMW increase in plant were obtained from treatment Mc than all the other treatments except with Mt where the fertilizer was applied on top of the mat. Higher DMW increase in roots and height were obtained from treatment Mc than all other treatments. Higher DMW increase in leaves was obtained from treatments applied with mulch mat in combination with fertilizers (Mt, Mc, Mb, CMt and CMb) than other treatments. Higher stem diameter increase was obtained from treatments

applied with mulch mats in combination with fertilizers (Mt, Mc, Mb, CMt and CMb) than all the other treatments. Mulch mat application have significantly improved moisture and temperature of sandy tin tailings, creating a better environment for root development and subsequently improve tree growth. The N nutrient uptake was higher in treatments Mt, Mc and Mb. The K uptake was higher in treatment Mc than all other treatments carried out. The P uptake was higher in treatments applied with mulch mats in combination with fertilize (Mt, Mc, Mb, CMt and CMb). Leaching of nutrients were rapid for N compared to nutrients K and P in all treatments applied with mulch mats. It was also found that the leaching of nutrients were higher in treatments where the fertilizer was applied on top and below the mulch mat. The soil properties after 4 months of mulching and fertilizer application were found to improve slightly in treatments where mulching was carried out. In general, there were no difference in using thicker or thinner mulch mats in terms of nutrient uptake and plant growth, except when they were incorporated with the fertilizer and applied underneath the mat in thicker mats. It was concluded that fertilizer incorporated inside the mat produced better plant growth, higher nutrient uptake, and less leaching of nutrients than fertilizer on top or below mat at time of planting. Mulching using thicker mats was better where the remaining weight after four months of application were higher than that of thinner mulch mats. Results showed that growth performances of the Acacia plants were found to be better when applied with mulch mats with fertilizer incorporated inside the mat (Mc). Treatment Mc was also able to reduce leaching of N, P and K through the soil than all other treatments.

Cost benefit analysis carried out on the cost of using the fertilizer incorporated mat on forest plantation per hectare basis showed a cost savings of 61.1 % compared to using EFB.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENGOPTIMUMAN PEMBUATAN TIKAR SUNGKUPAN DARI TANDAN KOSONG KELAPA SAWIT DAN KESANNYA TERHADAP PERTUMBUHAN POKOK AKASIA HIBRID YANG DITANAM DI ATAS TANAH PASIR BEKAS LOMBONG

Oleh

WAN ASMA IBRAHIM

Mac 2006

Pengerusi: **Profesor Madya Datin Rosenani Abu Bakar, PhD**

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Bagi penanaman hutan ladang di atas tanah berpasir seperti tanah pasir bekas lombong di Malaysia, kaedah menyungkup adalah penting terutamanya di peringkat pemindahan anak benih. Ini adalah bagi tujuan mengawal kelembapan, melindungi permukaan tanah dari hakisan akibat hujan lebat dan angin, mengawal suhu permukaan tanah, mengurangkan larut lesapan nutrien dari baja dan mengawal rumpai. Tandan kosong kelapa sawit telah pun dikitar semula sebagai bahan sungkupan dan sebagai sumber nutrien diladang kelapa sawit. Ia juga berpotensi untuk digunakan diladang hutan yang ditanam di atas tanah berpasir. Sifat semulajadi tandan kosong kelapa sawit ini adalah berat, berduri dan tidak sesuai disimpan lama. Oleh itu, tandan kosong kelapa sawit ini perlu di proses ke dalam bentuk yang lebih sesuai dan ekonomik untuk digunakan sebagai bahan sungkupan. Walaupun ianya telah diproses dan dikomersilkan ke dalam bentuk tikar sungkupan yang lebih ringan dan sesuai, ianya didapati terlalu nipis dan telah kehilangan ciri semulajadinya. Oleh

sebab itu, suatu tikar sungkupan yang lebih tebal dengan ciri yang lebih baik perlu di bangunkan.

Kajian awal telah mendapati bahawa tikar sungkupan dari serabut tandan kosong kelapa sawit boleh dihasilkan dengan menggunakan perekat yang membenarkan pereputan. Bagaimanapun, kaedah optimum bagi menghasilkan tikar sungkupan dengan ketebalan yang di perlukan tidak dikaji dan pengetahuan mengenai pereputan dan kesan aplikasi terhadap pertumbuhan pokok sangat kurang. Oleh itu, objektif kajian ini adalah untuk, (i) menentukan parameter optimum bagi pembuatan tikar sungkupan dari tandan kosong kelapa sawit yang lebih tebal, berupaya menyerap dan menyimpan air dan mereput secara perlahan, (ii) mengkaji pereputannya dan (iii) menentukan kesan aplikasinya terhadap pertumbuhan pokok Akasia hibrid yang ditanam di atas tanah pasir bekas lombong.

Dalam menentukan parameter optimum pembuatan tikar sungkupan setebal 2 dan 4 cm, rawatan yang dikaji ialah, (i) dua jenis perekat iaitu kanji dan polivinil asetat, (ii) empat kadar tekanan iaitu 750, 1000, 1250 dan 1250 psi, (iii) tiga kepekatan perekat iaitu 1, 3 dan 5% dan (iv) dua tempoh masa mampatan iaitu 2 dan 4 min bagi perekat kanji dan 1 dan 2 min bagi perekat polivinil asetat. Tikar sungkupan yang dihasilkan di label mengikut jenis perekat dan ketebalannya dimana tikar sungkupan yang dibuat dengan perekat kanji dengan ketebalan 2 dan 4 cm masing-masing dilabel MAT S2 dan MAT S4. Manakala tikar sungkupan yang dibuat dengan perekat polivinil asetat dengan ketebalan 2 dan 4 cm masing-masing di label MAT P2 dan MAT P4.

Kandungan kimia, kadar serapan dan simpanan air tikar sungkupan tersebut juga telah ditentukan. Keputusan menunjukkan bahawa kepekatan perekat dan tempoh mampatan yang sama, iaitu 3% dan 2 min diperlukan untuk pembuatan MAT S2 dan MAT S4. Manakala tekanan yang berbeza diperlukan iaitu 1250 dan 1000 psi bagi pembuatan MAT S2 dan MAT S4 mengikut urutan. Bagi pembuatan tikar sungkupan menggunakan perekat polivinil asetat pula, pembuatan MAT P2 memerlukan 3% perekat polivinil asetat, tempoh mampatan selama 1 min dan kadar tekanan 1250 psi. Bagi pembuatan MAT P4 pula, 3% perekat povinil asetat, tempoh mampatan selama 2 min dan kadar tekanan 750 psi diperlukan. Tempoh pengeringan yang di perlukan bagi tikar sungkupan yang menggunakan perekat polivinil asetat didapati lebih singkat berbanding perekat kanji. Secara amnya, kandungan kimia kesemua tukar sungkupan yang dibuat adalah serupa (tiada pebezaan yang ketara) dengan nilai julat 0.42 - 0.67% N, 0.10 -0.67% P, 2.09 - 3.09% K, 30.9 – 36.8% C, 0.14 - 0.28% Mg dan 0.18 - 0.26% Ca. Kadar serapan air paling tinggi telah didapati dari MAT P4.

Memandangkan tikar sungkupan ini berbentuk organik, ianya akan mereput dan berupaya menambah bahan organik kepada tanah, jadi, proses pereputan MAT S2, MAT S4, MAT P2 dan MAT P4 telah di kaji untuk menentukan kadar pereputan dan corak pelepasan nutrien kedalam tanah. Kajian ini telah dijalankan selama 6 bulan dengan meletakkan tikar sungkupan tersebut di atas tanah pasir bekas lombong yang diisi di dalam bekas. Kajian ini telah dijalankan dibawah teduhan dengan penambahan air yang terkawal. Kaedah pengsampelan musnah telah dilakukan setiap dua minggu ke atas tikar sungkupan yang dikaji, bagi penentuan kadar kehilangan

berat jisim kering, pH, kandungan kimia (C,N, P, K, Ca dan Mg), lignin dan holoselulosa. Keputusan kajian menunjukkan bahawa kadar pereputan tikar sungkupan MAT P4 adalah lebih rendah berbanding tikar sungkupan yang lain. Walaubagaimanapun, kadar kandungan kimia dan corak pelepasan nutrien adalah serupa. Oleh itu, berdasarkan tempoh kering selepas pembuatan yang lebih singkat, kadar serapan air yang paling tinggi dan kadar pereputan yang paling rendah, MAT P4 telah dipilih untuk aplikasi ke atas pokok Akasia hibrid untuk kajian seterusnya.

Satu kajian lapangan telah dijalankan dengan menggunakan 'mini lisimeter' untuk menentukan objektif yang ketiga. Pokok Akasia hibrid telah ditanam di dalam bekas yang diisi dengan tanah pasir bekas lombong, diletakkan di kawasan lapang dan dibiarkan tumbuh selama 4 bulan. Kaedah menyungkup dengan pembajaan yang berbeza telah dijalankan ke atas pokok-pokok tersebut dengan menggunakan MAT P4 (M) dan tikar sungkupan komersil (CM). Sembilan jenis rawatan telah dijalankan iaitu, (i) Pasir sahaja (S), (ii) Pasir dan baja (Sf), (iii) MAT P4 sahaja (M), (iv) MAT P4 dengan baja diletakkan di atasnya, (Mt), (v) MAT P4 dengan baja diletakkan di dalamnya (Mc), (vi) MAT P4 dengan baja diletakkan di bawahnya (Mb), (vii) tikar sungkupan komersil sahaja (CM), (viii) tikar sungkupan komersil dengan baja diletakkan di atasnya (CMt) dan (ix) tikar sungkupan komersil dengan baja diletakkan di bawahnya (CMt). Cecair larut lesap telah di kumpulkan setiap dua minggu dan di analisa. Parameter yang di ukur termasuk kandungan lembapan tanah dan tikar sungkupan semasa aplikasi, suhu tanah, ketinggian pokok, garis pusat batang pokok, berat kering jisim pokok selepas tuai, kadar serapan nutrien N, P, K, Ca dan Mg

pokok, kandungan N, P dan K didalam cecair larut lesap dan sifat tanah sebelumdan selepas tuai.

Hasil kajian mendapati bahawa MAT P4 (M) yang lebih tebal telah dapat menyerap dan menyimpan air dan mengawal suhu dengan lebih baik berbanding tikar komersil (CM). Pertumbuhan pokok yang lebih baik dari segi peningkatan berat jisim kering dan penyerapan nutrien telah di dapati dari pokok yang menggunakan tikar sungkupan bersama dengan baja. Peningkatan berat kering jisim paling tinggi telah didapati dari rawatan Mc berbanding semua rawatan lain kecuali rawatan Mt. Manakala peningkatan berat kering akar dan ketinggian pokok paling tinggi telah didapati dari rawatan Mc. Peningkatan berat kering daun dan garispusat batang pokok paling tinggi telah didapati dari pokok yang menggunakan tikar sungkupan bersama dengan baja (Mt, Mc, Mb, CMt dan CMb) berbanding rawatan yang lain.Aplikasi tikar sungkupan telah berupaya meningkatan kelembapan dan mengawal suhu dengan lebih ketara ke atas tanah pasir bekas lombong berbanding rawatan tanpa tikar sungkupan dengan menghasilkan persekitaran yang lebih baik bagi pertumbuhan akar sekaligus menghasilkan peningkatan pertumbuhan pokok yang lebih baik. Kadar penyerapan nutrien N paling tinggi telah di dapati dari rawatan Mt, Mc dan Mb. Manakala penyerapan nutrien K paling tinggi telah didapati dari rawatan Mc. Penyerapan nutrien P pula didapati paling tinggi dari rawatan Mt, Mc, Mb , CMt dan CMb. Larutlesap nutrien N adalah lebih cepat berbanding nutrient K dan P untuk semua rawatan. Larutlesap nutrient didapati paling tinggi bagi rawatan dimana baja diletakkan di atas dan di bawah tikar sungkupan. Ciri tanah setelah disungkup dan

dibaja selama 4 bulan didapati meningkat sedikit di mana tikar sungkupan di gunakan. Ketebalan tikar sungkupan tidak memberi perbezaan yang ketara dari segi penyerapan nutrien, tumbesaran pokok dan larutlesap nutrien kecuali apabila baja diletakkan di dalam tikar sungkupan dan diletakkan di bawah tikar yang lebih tebal. Kaedah aplikasi baja di dalam tikar sungkupan telah menghasilkan penyerapan nutrien dan pertumbuhan pokok yang lebih baik dengan pengurangan kadar larut lesap nutrien berbanding kaedah pembajaan di atas dan di bawah tikar sungkupan. Penggunaan tikar sungkupan yang lebih tebal adalah lebih baik di mana berat jisim kering yang tinggal selepas empat bulan aplikasi adalah lebih tinggi berbanding tikar sungkupan yang lebih nipis. Hasil kajian menunjukkan peningkatan keseluruhan pertumbuhan pokok Akasia yang lebih baik telah didapati dari rawatan dimana baja diletakkan di dalam tikar sungkupan (Mc). Rawatan Mc juga telah berupaya mengurangkan kadar larut lesap nutrien N, P dan K ke dalam tanah berbanding rawatan lain.

Pengurangan kos sebanyak 61.1% telah didapati dari penggunaan tikar sungkupan yang mempunyai baja di dalamnya berbanding penggunaan tandan kosong kelapa sawit ke atas satu hektar ladang hutan.

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I certify that an Examination Committee has met on March 28th 2006 to conduct the final examination of Wan Asma Ibrahim on her Doctor of Philosophy thesis entitled "Optimization of Mulch Mat Production from Oil Palm Empty Fruit Bunches and its Effects on Growth Performance of Acacia Hybrid Seedlings on Sandy Tailings" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

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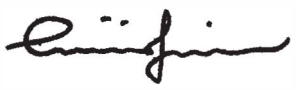

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Date: 13 JUL 2006

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions

WAN ASMA IBRAHIM

Date: 13/6/06

TABLE OF CONTENTS

LIST OF TABLES